Anaerobic Digestion and Biomethane Production from Lignocellulose

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Abstract

The synthesis of bio methane through anaerobic digestion using lignocellulosic material as the substrate has a high potential for converting biomass into renewable energy. However, the native lignocellulosic biomass is resistant to microbial hydrolysis due to its recalcitrance, which lowers the efficiency of bioconversion of organic matter into biogas. Therefore, a critical analysis of the relationship between lignocellulose properties and bioconversion effectiveness is required. The process of anaerobic digestion and its rate limiting step, the structural and compositional characteristics of lignocellulosic biomass, recalcitrance and lignocellulose inhibitors, and their major impacts on anaerobic digestion for the production of bio methane are all comprehensively summarised in this review. Additionally, several pre-treatment techniques used on lignocellulosic biomass were thoroughly reviewed in order to contribute to cell wall disintegration and increase bio methane outputs. According to current knowledge, the main drawbacks of these pretreatment procedures are their high energy input and expense needs. In addition to improving the fermentation process, additional research needs to be done on the key structural influences of biomass recalcitrance and the effectiveness of anaerobic digestion, both of which will improve the synthesis of bio methane from lignocellulose.

Keywords: Bioconversion • Anaerobic digestion • Lignocellulose • Renewable energy • Fermentation

Introduction

Lignocellulose, which may be made from agricultural, forestry, and urban wastes, is one of the most plentiful organic renewable resources, with a growing yearly supply of 200 billion tonnes. Lignocellulose is a possible substrate for the manufacture of second generation bioenergy, including bioethanol and bio methane, due to its notable availability and low cost. One of the most widely used most affordable processes for producing energy from lignocellulosic cellulose is the manufacture of bio methane.

Description

Anaerobic digestion, a naturally occurring biological process that can be broken down into four phases, produces bio methane. Complex organic polymers are first broken down into their constituent amino acids, fatty acids, and sugars at the start of the process. Fermentative bacteria then transform these monomers into a variety of short chain volatile fatty acids (acidogens).

The volatile fatty acids are further transformed by acetogenic bacteria or acetogens into acetate, carbon dioxide, and hydrogen, which serve as organic substrates for methanogenesis, the process that produces bio methane. The AD process has the potential to break down the organic portion of any feed stocks, including lingo cellulosic feed stocks, animal and crop waste, and food waste, to produce bio methane. However, the amount of methane produced depends substantially on the substrate type. The main difficulty is the intricacy of the biomass structure, which renders lingo cellulosic biomass extremely resistant to anaerobic breakdown and ultimately leads to low bio methane output. Native lignocellulose has recalcitrant anti-degradation properties known as biomass recalcitrance, which severely hinders hydrolysis during the initial stage of anaerobic digestion and, ultimately, limits the commercial production of bio methane from lignocellulose. Lignocellulose needs to be pretreated in order to get beyond this resistance, and numerous pretreatment techniques have been created recently. The advantages of different pretreatments (such as surface area increase, lignin removal, and decreased cellulose crystallinity) have been discussed elsewhere. For further bio methane development, a comprehensive evaluation and assessment of the effects of lignocellulose recalcitrance on anaerobic digestion and bio methane production is still required. Determining the proportional impacts of lignocellulose recalcitrance on anaerobic fermentation and bio methane generation is the goal of this study, which aims to provide a thorough assessment of the topic. Additionally, future prospects and technology for accelerating lignocellulose anaerobic digestion were reviewed.

Conclusion

Lignocellulose substrate exhibits excellent bio methane generation capability. The plant cell wall's inherent complexity and recalcitrance prevent lingo cellulosic biomass from being used effectively during the anaerobic digestion process. The accessible surface area of biomass, which is created by its chemical compositions, which create a spatial network as a protection barrier, is typically the direct component impacting hydrolysis. By lowering the substrate's accessibility to enzymes or chemical regents, it has a more significant function in minimising the early enzymatic hydrolysis. Higher surface availability will come from the elimination of partial cell wall components and an increase in accessible surface area throughout the anaerobic digestion process. The substrate's ability to decompose will then be more severely limited by indirect factors such chemical compositions (lignin, hemicelluloses, and acetyl group) and characteristics related to the structure of cellulose (cellulose crystallinity and degree of polymerization). Different influencing elements are not isolated, but rather tightly coupled to one another and have a synergistic effect on bioconversion as cross linked polysaccharide networks. There are still certain fundamental concerns that require more research, particularly for the decomposition process in anaerobic digestion, even if there is a great deal of knowledge regarding the structure of the plant cell wall and recalcitrance.

Current methods are helping to increase the synthesis of bio methane from lignocellulose. Pretreatment is still the most efficient way to deal with biomass resistance, and choosing the right pretreatment technique is essential for producing industrial quantities of bio methane. The biggest drawbacks, however, are the high energy input and expensive costs of decomposing biomass resistance. A significant improvement in both biomass quality and conversion efficiency is essential for the economically viable generation of bio methane from lingo cellulosic feed stocks. Therefore, future research should concentrate considerably more on determining how the specific structure of cell wall resistance and the primary factor influencing the anaerobic digestion process are related. This information will be utilised to explore new strategies to increase bio methane production. Recent studies have shown that artificial energy production and plant cell wall modification are exciting techniques for enhancing the quality, quantity, and digestibility of conventional biomass material. Transgenic plants may be used regularly in the anaerobic digestion system for the production of biome thane as a result of the advancement of biotechnology.

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